Interoperability Problems Caused by Transitioning to a Service Oriented Environment

Chris Black, Dick Brown, Stan Levine, Bill Sudnikovich
Simulation to C4I Interoperability (SIMCI)
christopher.black1@us.army.mil

Abstract

A major Department of Defense challenge continues to be the synchronized interoperability of multiple command and control and M&S programs. The Army has three major Command and Control (C2) efforts to contend with: ABCS migration, FCS development, and the Joint Net Enabled Command and Control (NECC) program. These C2 systems will be operating in a Service Oriented Environment (SOE) that will be implemented/fielded in phases over time. There is no single process that is aligning these efforts at a level that includes totally synchronized technical exchanges of standards, data, and re-use of components. Two of the Army's key M&S initiatives also have development cycles that do not parallel the C2 schedules and do not yet fully address operating in a SOE. The JLCCTC development has to date been on an annual development cycle but is currently moving to a 2 year cycle. The other big M&S initiative, LVC-IA, is developing a prototype system with a target date of FY10. Integrating all of these phased C2 and M&S programs will require innovative technical and programmatic methods.

1. Introduction

A major Department of Defense challenge continues to be the synchronized interoperability of multiple Command and Control (C2) and M&S programs [1][3]. The Simulation to C4I Interoperability (SIMCI) program has been addressing this problem successfully for many years [2]. However, this problem is being exacerbated by the unsynchronized insertion of new technology. C2 systems are migrating to a Service Oriented Environment (SOE) that will be implemented/fielded in phases over time. Also M&S systems will have to migrate their interfaces in order to effectively simulate and stimulate C2 systems. However, they will have to be able to support interfaces to different SOE implementations and also pre-SOE implementations at the same time. Integrating all of these phased C2 and M&S programs will require innovative technical and programmatic methods.

This paper will address the critical operational requirements that impact SOE implementation. It will then describe current plans and interoperability impacts. Technical challenges and potential solutions are addressed in detail.

2. Operational Requirements

2.1 A historical perspective on requirements for M&S and C2 systems.

The Battle Command Training Program was the first organization to propose a requirement for simulations to support training for Command and Control C2. The Battle Command Training Program (BCTP), the Army's capstone combat training center, is located at Fort Leavenworth, Kansas. BCTP supports realistic, stressful training for Army Service Component Commanders/Army Forces, Corps, Division, and brigade commanders and supports Army components participating in joint exercises to assist the Chief of Staff of the Army in fulfilling his duties to provide trained and ready units to win decisively on the modern battlefield and to conduct contingency operations worldwide. BCTP uses simulation centers worldwide to train commanders and staffs.

At Ft. Leavenworth, where much BCTP work is done, the National Simulation Center (NSC) was created to support BCTP exercises. The NSC and the Jet Propulsion Laboratory developed Corps Battle Simulation (CBS) to drive analog training events. As the Army Battle Command System (ABCS) began to be fielded to units, CBS became suboptimal for digital exercises and a requirement for new simulation, Warfighter Simulation (WARSIM) emerged.

The WARSIM operational requirements documents said that WARSIM is "Designed and built using modern computer technology, modern software engineering techniques, and validated algorithms and

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
20 MAY 2008	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Interoperability Problems Caused by Transitioning to a Service Oriented Environment	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Simulation to C4I Interoperability (SIMCI) US Army**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
AFCEA-GMU C4I Center Symposium "Critical Issues In C4I" 20-21 May 2008, George Mason University, Fairfax, Virginia Campus, The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**20**	

databases, it will allow units worldwide to train using their organizational equipment." The problem was that the requirement was written in isolation [4]. It did not clearly define the requirement to stimulate the C2 system. C2 system requirements suffered the same characteristic: the earlier operational requirements did not clearly identify the need for a simulation that would connect to the C2 system to do the following:

- Support wargaming for the military decision making process
- Simulate subordinate and parent unit headquarters to drive training exercise
- Perform the digital bookkeeping for after-action reviews

In 2005, the TRADOC Program Integration Office for Battle Command published the Battle Command Information System Migration Plan. That document was endorsed by the Army G-3 and, at his direction, was re-written into an Initial Capabilities Document. The latter contained a section on training that was prefaced with the following the statement: "In order to achieve acceptable digitally-enhanced training environments, the Command, Control, Communications and Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) systems must be seamlessly integrated and able to interoperate with simulations, simulators, and instrumentation systems to support the time-phased modernization to a Modular Force structure."

This had the effect of expanding the role of simulations. It said that all C2 systems had to be "seamlessly interoperable" with the C2 systems. The scope was not just focused on the brigade combat team, divisions and corps. It now transgressed the spectrum of echelons from platoon to the joint task force.

2.2 The training challenge of the Live-Virtual-Constructive (LVC) training environments.

2.2.1 Training, exercises, and military operations (TEMO) domain

Training simulations belong to a "domain" of models and simulations called "TEMO."

One of the three domains for Army M&S applications. the TEMO domain includes most forms of training at echelons from individual simulation trainers through collective, combined arms, joint, and/or combined exercises. The TEMO includes mission rehearsals and evaluations of all phases of war plans.

Within training simulations, there are three categories:

- Live simulations. Characterized by a "live" situation where the opposing force is real and the organization being trained uses their organic equipment. Real bullets are replaced with laser inserts on the guns and rifles. The C2 suite associated with the players is the "real thing." Instrumentation of the range provides the scoring and assessment of how effective the unit was. Live simulations are highly effective for training formations up to the Brigade Combat Team (BCT) echelon.
- Virtual simulations. Characterized by a simulator that is a mock-up of a piece of equipment. An example of a virtual simulator is a helicopter simulation that has all the fidelity of a real attack helicopter. Virtual simulations are highly effective for training individual Soldiers or a crew of Soldiers on a particular piece of equipment, e.g. a tank. Selected virtual simulators can also be networked to create a virtual battlefield to train combat tasks at the platoon, company, and battalion level.
- Constructive simulations. Constructive simulations are more abstract. They use the organization's real battle command system including the communications; however, the simulation creates a virtual reality for the organization being trained. A battle captain and other staff members being trained at the brigade echelon are presented with subordinate and parent headquarters as well as an opposing force. The simulation can run in real time as well as slower or in "fast-forward." While a constructive simulation such as OneSAF, can be run at the lowest echelons, constructive simulations are most effective in situations where it is impractical to field all the organizations' command posts and TOCs. Constructive simulations also serve another purpose, no less important than training. Constructive simulations can be

used for wargaming courses of action in the military decision making process.

2.2.2 Advanced concepts and requirements (ACR) domain

The second of the three domains for Army M&S applications, ACR includes experiments with new concepts and advanced technologies to develop requirements in doctrine, training, leader development, organizations, materiel and soldiers that will better prepare the Army for future operations. ACR evaluates the impact of horizontal technology integration through simulation and experimentation using real soldiers in real units.

The ACR domain exists in organizations such as the TRADOC battle laboratories and TRADOC Analysis Command (TRAC). TRAC has developed the Advanced Warfighting Simulation (AWARS) which is used for TRAC's analyses of alternatives. The Battle Command Battle Laboratory is one of TRAC's customers for AWARS. The Battle Lab uses AWARS for experiments such as the Division Warfighting Experiment.

2.2.3 Research, Development, and Acquisition (RDA) domain

RDA is the final of the three domains for Army M&S applications. The RDA domain includes all models and simulations used for design, development, and acquisition of weapons systems and equipment. Models and simulations in the RDA domain are used for scientific inquiry to discover or revise facts and theories of phenomena, followed by transformation of these discoveries into physical representations. RDA also includes test and evaluation (T&E) where models and simulations are used to augment and possibly reduce the scope of real world T&E.

An example of a simulation in the RDA domain is a model used to represent live fire against soldiers and their equipment. RDA also includes models for financial and cost analyses. These are all considerations in acquiring the capabilities we need. The next section looks at the process for putting systems in the hands of the customers.

2.3 Documenting an Integrated Approach:

How to get from a capabilities document to a composite of C2 systems and simulations that interoperate "seamlessly." The DoD has directed a capabilities-driven approach for improving the systems to be used by the Combatant Commands.

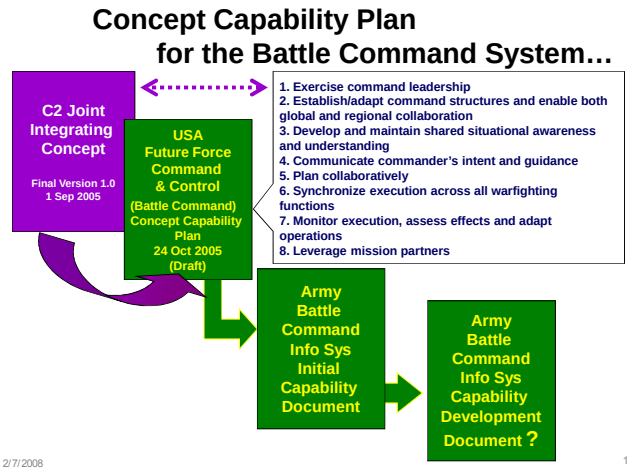


Figure 1. Capability Documenting

Figure 1 shows DoD's process for documenting a new capability. "Capability" needs a definition as well:

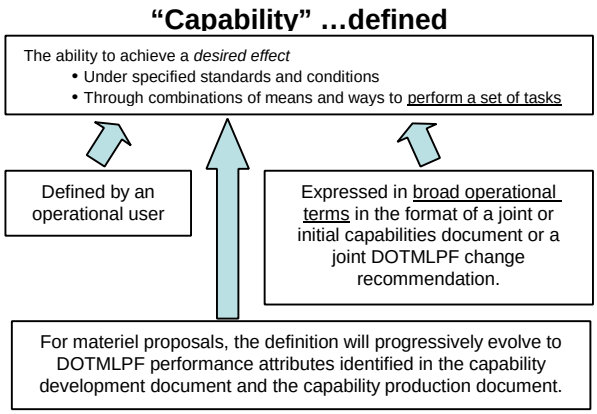


Figure 2. Capability Definition

Figure 2 shows the official definition of "Capability". Note that the capability is not just a materiel requirement; it emphasizes all of the Doctrine, Organization, Training, Logistics, Materiel, Personnel and Facilities (DOTLMPF) functional areas. The challenge for the Army becomes one of getting multiple agencies to first, arrive at a common understanding of what the customer (Combatant Commander) needs and how to build and integrate the individual pieces of a very complex system.

In terms of C2 systems and M&S materiel, the Army must tap at least two Program Executive Offices (PEOs): Command, Control and Communications-

Tactical (C3T) and Simulation, Training, and Range Instrumentation (STRI) and their Program Managers (PM). The capability that ultimately goes from the TRADOC proponent to the PMs has to be universally understood. Accompanying the situation is getting funds for the variety of systems including dollars to do the integration work so that customer's expectations are met. This means that the "Pentagon" must understand the objective capability and what the effect of not funding components is.

The capabilities document that originates in TRADOC has allied documents as well that help to amplify the need. These include the Simulation Support Plan; the System Training Plan and the MANPRINT Management Plan. These three documents are inter-related although they can stand alone. The MANPRINT Management Plan explains who the users of the systems will be; the System Training Plan says how the Army plans to train Soldiers and units to use the system; finally, the Simulation Support Plan provides a guide on how simulations should be used throughout the materiel acquisition, testing, training and ultimately as components of the Battle Command System.

The last point is critical and summarizes the stated requirement for M&S and Battle Command. The Battle Command Information System's Migration Plan describes the requirement as follows:

"Embedded Modeling and Simulations for Operations and Training: Current appended and umbilical systems cause interoperability problems. Use embedded simulation applications and infrastructure components to improve the Military Decision Making Process (MDMP). This will enhance the operational lethality of BC systems. Simulation components that will enhanced the MDMP and Course of Action (COA) development and war gaming are execution monitoring, mission rehearsal, After Action Review (AAR) support, archival training files, etc. In BC systems using common components, simulation functions such as robust 3D terrain/environmental representation should co-exist with BC applications so that the simulation can be used for "what-if?" situations. These must be displayed as a special situation on the common operating picture (COP). Embedded modeling and simulation components add automated features such as estimating fuel consumption, doing terrain mobility analysis, communication network analysis, etc. These features add to the war gaming capability. While it is possible to embed an entire simulation application, it is better to construct a shared BC and simulation component architecture. Common data, components and standards shared among simulations and BC applications is the key to achieving this."

2.4 Painting the Moving Train

The reason why there is a Battle Command Migration Plan is because there are C2 and M&S systems already fielded. We don't have luxury of stopping the train to put a new coat of paint on it; it has to be done in units that already have C2 systems and are presently engaged in combat operation.

The Army Force Generation process is a recent technique to meet the needs of the forces in harm's way. Units go through a period of stand-down during which their equipment is up-graded and the Soldiers are trained on new tasks. Subsequently, the unit completes a training certification event at a Combat Training Center and becomes ready for deployment. The third and final phase is the move to the area of hostility.

The PMs have the responsibility of ensuring that all the systems are integrated so that they can conduct operations as a part of the Joint Land Component Command (which typically has Marine Corps units and coalition partners). This is even more challenging because commanders in the field have chosen to build their own C2 systems. While the "home-grown" systems met individual commander's needs very well, planned interoperability is usually devastated.

3. C2 Transition Plans and Interoperability Impacts

The requirements identified and discussed in the previous section shape the acquisition process for our current and future warfighting systems. Experience shows that the current acquisition process is deficient in allowing the flexibility to fully support integrated development, test, and fielding in a system of systems architecture. This inhibits interoperability and increases the risks and challenges as we plan to migrate and transition to a net-centric environment. These architectural problems are readily apparent between C2 systems but are even further amplified when we attempt to integrate and interoperate with M&S systems.

This section of the paper will provide a brief overview of the current suite of Army Battle Command Systems (ABCS) and the future, emerging systems, the Future Combat System (FCS) and the Net Enabled Command Capability (NECC). We will also

look at current M&S systems and how they are being used. Following these overviews a description of the transition plans will be discussed and the impacts that these plans may have on interoperability requirements.

3.1 Army Battle Command System (ABCS)

The Army Battle Command System is a family of systems that provide the automation for the battlefield functional areas (BFAs) necessary to accomplish

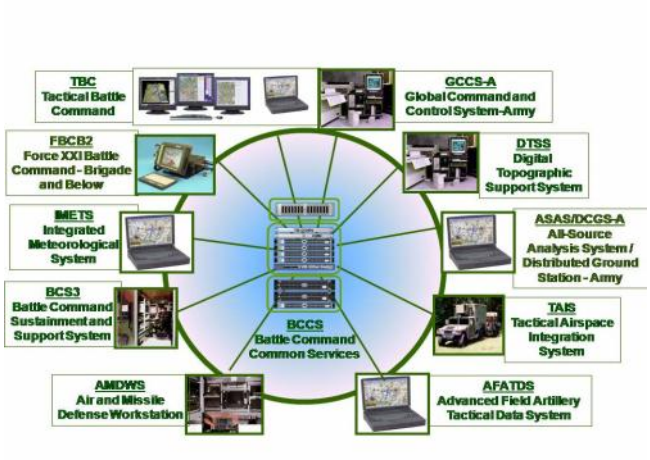


Figure 3. Army Battle Command System

warfighting missions across the spectrum of operations. There are ten systems defined in the current ABCS architecture. Figure 3 [Battle Command Migration Plan, PM Battle Command briefing, 12 April 2007] shows a high level view of these services as they are hosted on a Battle Command Common Services (BCCS) set of computers. These systems are primarily interconnected through a messaging protocol and routing service called the Publish and Subscribe Service (PASS), although there are a number of point to point specific interfaces still implemented. The current suite of ABCS serves information needs from echelon Theater down to Platoon and Squad level command and control needs.

3.2 Future Combat Systems (FCS)

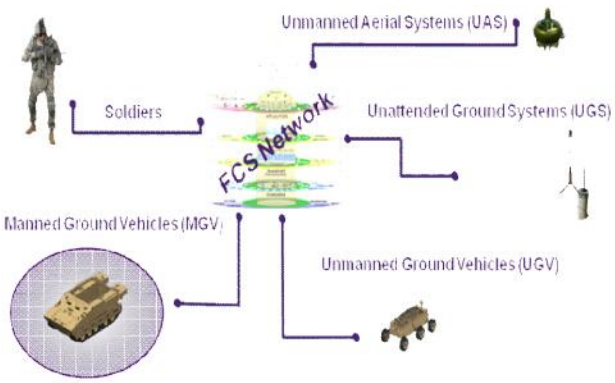


Figure 4. Future Combat System

The Future Combat System (FCS) is the Army's modernization program consisting of a family of manned and unmanned systems, connected by a common network, which enables the modular force, providing our Soldiers and leaders with leading-edge technologies and capabilities allowing them to dominate in complex environments [5]. Figure 4 is a highly abstracted view of the FCS functional component system types and their linkage to a set of network services and applications based on a foundation of standards. The FCS is a joint (across all the military services), networked (connected via advanced communications) systems of systems made up of initially 18 individual systems plus the network and Soldier (often referred to as 18 plus one plus one). The FCS will enable the future modular force, providing our Soldiers and leaders with leading-edge technologies and capabilities allowing them to dominate in complex environments. The FCS is focused at provide these capabilities at the echelons Brigade and below. The FCS schedule has been flexible based on funding priorities year to year. The fielding strategy to is provide early development successes to integrate with the ABCS systems as 'spin-off' technologies until the FCS can be fielded as a fully functional capability.

3.3 Joint Land Component Constructive Training Capability (JLCCTC)

The JLCCTC is a collection of integrated Simulation Models that stimulate Army Battle Command Systems (ABCS) to facilitate Command and Staff training. The JLCCTC is a federation of current and developing systems including Warfighters' Simulation (WARSIM), One Semi-Automated Forces

(OneSAF), Corps Battle Simulation (CBS), and Tactical Simulation (TACSIM) [6]. The JLCCTC provides the Army's primary set of simulation based training tools.

3.4 BC Migration Plan

A Battle Command Migration Plan has been developed and approved to provide a campaign plan for the transformation and development of Battle Command (BC) information system capabilities. The document provides guidance and direction on the vision, governance, and development of Battle Command information system capabilities. [Battle Command Information System Integration & Migration Plan, Version 1.7.2, 21 November 2005] The BC Migration Plan primarily focuses on the transition of the current ABCS systems as they evolve to support warfighter needs until the FCS and emerging NECC systems become available and fielded. The end state vision of transition is for the capabilities in the ABCS systems to be assumed by FCS and NECC with FCS serving echelons Brigade and below and NECC serving echelons Brigade and above.

3.5 Army Battle Command System Plan

The primary objectives of ABCS migration to its future architecture is a consolidation of services onto a Battle Command Common Services platform and the migration from the PASS to the Data Dissemination Service (DDS). The DDS ensures that data is visible, available, and usable when and where it is needed to accelerate decision-making. Part of the DDS is to also ensure tagging all data with metadata to enable users to discover the data. These characteristics enable the transition from a point-to-point communications architecture to a many-to-many architecture that aligns with the goals of net-centricity.

3.6 Net Enabled Command Capability (NECC) Plan

NECC will be the DoD's principal command and control information technology. NECC will enable decision superiority via advanced collaborative information sharing achieved through vertical and horizontal interoperability. NECC will support force-level planning, execution, monitoring, and assessment of joint and multinational operations. NECC will use Net-Centric Enterprise Services (NCES) core enterprise services and will be able to exchange information across multiple security domains. NECC draws from the C2 community to evolve current and provide new C2 capabilities into a fully integrated, interoperable, collaborative Joint solution [7]. NECC is evolving now through a technology demonstration phase that is seeking to harvest capabilities from different service systems into a loosely coupled, easily accessible enterprise structure.

There are many challenges, both programmatic and technical, that need to be addressed to achieve success in this migration. As mentioned previously these challenges are both technical and programmatic. The ABCS systems need to continue to evolve to support the warfighter until the FCS and NECC programs can be fielded. As ABCS evolves it needs to accommodate the technology insertions coming from the FCS program while maintaining its focus on emerging needs from the field. The Army is at war which has draining effects on many resources. The FCS and NECC are inherently Joint systems which imply the need to synchronize with systems from the Joint service community as well as meeting Army requirements. In addition, the M&S systems that support the capability development, research, testing and training of all of these systems has to be synchronized and resources as well.

3.7 Modeling and Simulation Systems Plan

M&S systems are currently developed and managed in categories defined as domains. The current M&S domains are Training, Exercises, and Military Operations (TEMO), Research, Development, and Acquisition (RDA), and Advanced Concepts and Requirements (ACR). The TEMO domain primarily supports training, the RDA domain primarily supports the research and early prototype development and also includes the testing community, and the ACR domain primarily supports concept development and evaluation to include experimentation. The management of Army M&S is directed by Army Regulation 5-11, "Management of Army Models and Simulations'. A new release of this document is forthcoming that has been revised to update policy with regard to new management processes, the establishment of integrating communities and other communities of interest; and changes pertaining to standards and the discontinued used of models and simulations. These updates will align the Army management of M&S with the recently created M&S Coordinating Office at the DoD level. The Army Modeling and Simulation Management Program (AMSMP) will facilitate Army compliance with DoD policy and guidance for net-centric operations and the

net-centric network. In this sense this program will provide the transition guideline for Army M&S to the net centric environment.

3.8 Live, Virtual, Constructive (LVC) Integrating Architecture Plan

The LVC-IA will provide the foundational structure and framework for integrating LVC systems into the Integrated Warfighter's Training Environment (the LVC Training Environment)(Figure 5). The objective of LVC-IA is to enable on-demand training, mission planning and rehearsals, C4ISR interaction, and Joint, Interagency, Intergovernmental and Multinational (JIIM) interoperability anytime and anywhere. The LVC-IA is a set of protocols, specifications, standards, and services/infrastructure that support the operation of a seamless and integrated LVC environment where hardware, software, network components, and modules are interoperable with other LVC components and the Battle Command systems [8].

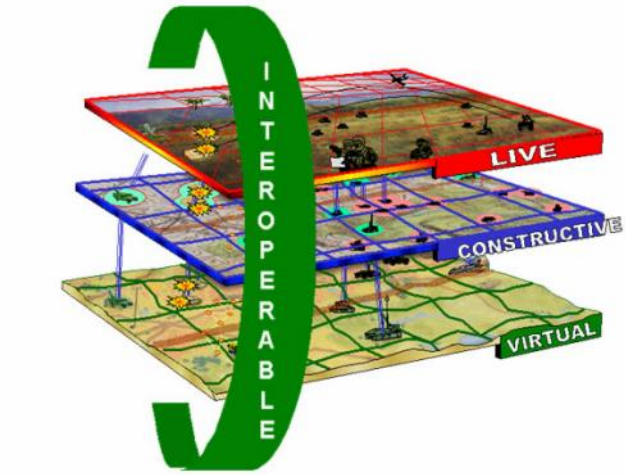


Figure 5. LVC-IA

The LVC-IA will allow the transition away from the narrowly defined domains as previously described for Army M&S and facilitate emerging technologies to provide advanced M&S capabilities. LVC-IA also explicitly identifies the need for interoperable interactions with live C4ISR systems which has often been an overlooked in early development and has spawned a variety of interface approaches that are inconsistent, lack standardization, and are costly to maintain.

4. Technical Challenges

In 2000 the Simulation to C4I Interoperability (SIMCI) Overarching Integrated Product Team (OIPT) described their vision of an interoperable M&S and C4ISR framework. The SIMCI vision, referred to as the house chart, is based on a common conceptual reference model accommodating common C4ISR component interfaces, common standards and tools, and aligned architectures, all linked via a common information management process to provide common, shared solutions for the C4ISR and simulation communities. This paper will use the separate components of the house chart as depicted in figure 6 to address some of the technical challenges the Army will need to solve as it transitions its battle command and M&S systems from their current to future state.

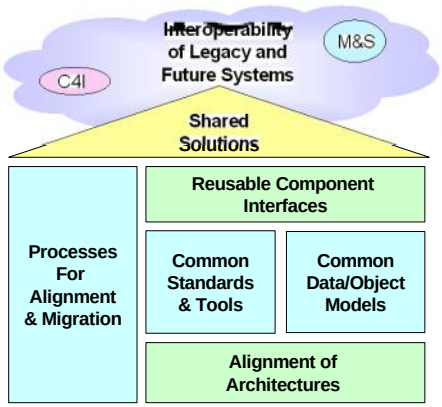


Figure 6. SIMCI House Chart

4.1 Processes for Alignment & Migration

A major challenge continues to be the synchronization of multiple command and control and M&S programs. As depicted in figure 6 processes work in parallel to the other components of the house chart to facilitate the coordination of common standards and tools, common data models, architectures, and co-use of applications and services. As we look at the Army's three major axis's: ABCS migration, M&S migration and FCS, and DISA's NECC program it is difficult to identify a single process that is synchronizing these efforts at a level that encourages technical exchanges of standards, data, and re-use of components. ABCS is driven by the Software Blocking Program which endeavors to manage the operational, systems, and technical architectures of all iterations of ABCS, aviation, and

intelligence systems the Army develops. In cases of standards such as military message versions this is effective however since these plans are developed several years prior to block execution they do not reach down to the application or service level. Additionally only systems designated for a specific block are required to abide by the technical architecture for that block and there are numerous weapon platforms, M&S, and emerging systems that are not included. Two of the Army's key M&S initiatives have development cycles that do not parallel Software Blocking schedules. JLCCTC development, co-managed by the Army's National Simulation Center and PEO STRI, has to date been on an annual development cycle but is currently moving to a 2 year cycle. SWB cycles tend to be 1.5 years but can fluctuate based on unit rotations and technical challenges. The other big M&S initiative, LVC-IA, is developing a prototype system at Fort Bliss with a target date of FY10 and acknowledges its development will be impacted by a number of different programs. How it will manage these external impacts is unclear. FCS has a separate development plan managed by the LSI. They have implemented "spin-outs" to develop interoperability with other Army systems as part of that plan. Coordinating the dates of the spin outs with ABCS and M&S development cycles will be challenging, especially since FCS is the big gorilla in the room and has its own milestones to meet. Lastly DISA's NECC is developing capability modules that will be developed over three increments with the first increment complete by FY10. ABCS is the primary Army system that will interface with NECC but parts of the M&S community and eventually FCS will also need this capability. Each of the separate programs (ABCS, M&S, FCS, and NECC) have complex internal synchronization plans however what doesn't exist is a process to synchronize across all four programs. This is not say there is no technical exchange occurring, the FCS and M&S community (OneSAF program) have a close relationship since OneSAF is designated as the embedded M&S driver for FCS. In fact some of the OneSAF applications are incorporated into FCS's System of Systems Common Operating Environment (SOSCOE) which should facilitate FCS to JLCCTC interoperability when the time comes.

4.2 Alignment of Architectures

The Army battle command community is in the process of migrating from a message based, client server architecture to a Service Oriented Architecture (SOA)(Figure 7). ABCS will undergo a significant change in architecture in software block 2+ (FY08/09) as it implements Data Dissemination Services (DDS) and FBCB2 Joint Capabilities Release (JCR). In fact ABCS has been progressively moving from military standard messages (JVMF/USMTF/FDL/TADL) to use of publish and subscribe and Microsoft exchange for data dissemination for the past several years.

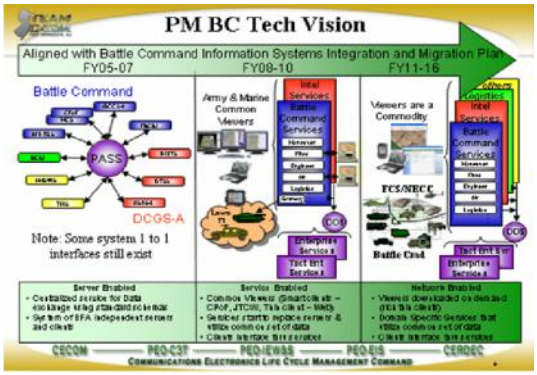


Figure 7. PM BC Tech Vision

An often forgotten component of battle command and its architecture is the supporting communications backbone which is the Army's LandWarNet (LWN) which is also undergoing a complete modernization from line of sight radios to greater dependence on satellite based systems. This also has a significant affect on battle command's architectures. M&S, on the other hand, stimulates battle command solely through use of military messages and has no set plans to incorporate DDS or even a SOA. In time M&S will not be able to properly stimulate Army battle command systems because the flow of information (format and inject points) is critical to the proper distribution of information within and across Tactical Operation Centers (TOCs). The Army's training philosophy is "train as you would fight" and reconfiguring battle command systems to accommodate inaccurate stimulation by M&S would be negative training. Clearly the M&S community requires some forcing function be put in place for it to change. FCS's architecture is essentially a microcosm of the whole Army including the functional areas of battle command, logistics, intelligence, fires, and embedded training,. Managing these functional areas to include their internal and external interfaces is the FCS SOSCOE. Interoperability of ABCS, M&S, and FCS will require that current Army systems across the functional areas have two way interoperability with the FCS SOSCOE. A major challenge will be development of OAs, SAs, and TAs that describe the needed relationships of the three major programs.

4.3 Common Data

The close coupling of battle command systems among themselves (ABCS and FCS) and with M&S systems has emphasized the need for common data to a greater degree than ever before. Data falls within numerous categories such as geospatial, weather, imagery, organizational, mission planning, and orders. A dated but still relevant discussion of data categories is "Interim Report of C4I-Simulation Technical Reference Model Study Group", Paper 01F-SIW-094, 2001 Fall Simulation Interoperability Workshop, Orlando, FL, September 2001. The common understanding of data by different systems remains an issue even in an organization like the military which is suppose to be known for its regimentation. A "tank" can still be an armored fighting vehicle, a water reservoir, or a separate receptacle for some liquid. Restrictions on type and number of characters in each model and lack of a standardized naming convention that supports all models continues to be an obstacle, as do multiple standards, formats, and ontology used by each system or family of systems. An example of the complexity of this problem is in the Army's effort to tackle just the common data elements between battle command and M&S systems as part of the initialization process. This subset of data is primarily the force data (units, soldiers, and equipment), the units' system architecture, and the digital systems and network data associated with that particular unit. Correlating the battle command data bases and the supporting M&S data bases is critical for proper stimulation and to avoid false or unknown units displaying on battle command boxes. Building battle command data bases from scratch today still takes four to five months, as do M&S data bases. In the Army's vision to train and fight mixed forces (current and FCS) support by M&S for training, course of action analysis and mission rehearsal; rapid and accurate data initialization is a critical requirement. Regardless the Army has been extremely slow to recognize and address the initialization problem.

4.4 Common Standards

Establishing common standards that can be adopted by a number of separate programs of record all in different stages of development is a continual challenge. A good example is the JC3IEDM standard initially approved by the Army G3 in FY05 (then called the C2IEDM). Implementation of the policy has taken over two years to date and in the mean time while some new systems have adopted the standard, others have not. Current systems are not required to adopt the JC3IEDM internally however they are required to use it when exchanging data externally with another family of systems. A conflicting issue is that PMs are similarly encouraged to adopt existing applications, components, and services to save resources but these existing tools may or may not use the required JC3IEDM standard. So cost savings may, and often do, trump standardization. Today ABCS is using unique data standards, a result from having been built from many disparate systems. Recently however ABCS announced it plans to develop a Universal Core data model which is not JC3IEDM compliant. FCS has announced it will use a JC3IEDM compliant data model, a step in the right direction. On the other hand M&S has numerous data models none of which are JC3IEDM compliant, and no plan to move towards a single data standard. As battle command, FCS, NECC, and M&S develop and migrate, decisions on standards are required to avoid the need for 1 to n data exchange solutions. The lack of clear and enforceable guidance across the systems will result in mismatches and the continual development of data mapping tools.

4.5 Reusable Component Interfaces

A long term goal of the SIMCI OIPT has been to encourage common use of components between battle command systems and M&S to facilitate interoperability and reduce costs. In FY00 the SIMCI OIPT funded an effort by several simulation interface developers to integrate and the ABCS Common Software's Common Message Parser (CMP) to build and exchange messages with battle command systems. This effort was a success and at least four interfaces continue to use the CMP in their systems. Despite the success of this project little other co-use of components by either M&S or BC has occurred. Logically movement to a SOA should encourage the co-use of services by each program as long as other issues such as metadata, data exchange models, and security are also coordinated. However there are many other opportunities where co-use of products should and need to be implemented. A single initialization process for both battle command and M&S accessing the same data base to avoid data mismatches must be implemented for M&S systems, ABCS, and FCS. Both battle command systems and M&S systems use terrain which must be correlated between the two for proper stimulation yet there is no common terrain or geospatial development tool. FCS' embedded training capability includes after action review tools which must be able to collect and share data with current BC and M&S systems for mixed force training exercises.

What is lacking today is a comprehensive list of possible co-use opportunities or the means to implement them.

4.6 Technical Challenges Conclusion

Ensuring cost effective, interoperability of ABCS, FCS, and M&S systems as they migrate will involve many more technical challenges than the examples highlighted in this section. The key to identifying those challenges is use of a framework like that developed in the house chart coupled with an effective process that not only identifies the challenges but develops coordinated and integrated solutions.

5. Potential Solutions

The bottom line of any solution must be that the organization's people and equipment must effectively interoperate. This is a requirement that is focused on location and date. A specific Unit's equipment, personnel, superior unit, and subordinate units are not standard and can change over time. For example, the interoperability requirements for Units in Korea in 2008 can be different from the interoperability requirements for Units in Iraq in 2009. Therefore, any enterprise wide solution must take into consideration the interoperability requirements caused by the deployment of system versions.

5.1 Technical Solutions

Since simulations have to simulate and stimulate C2 systems they have the same interoperability requirements as a minimum. Technical solutions will have to address interoperability using Bit oriented messaging, Character oriented messaging, Database data exchanges, and Service Oriented information exchanges. The problem is that there are many standards being used and many different versions of standards that change over time.

5.1.1 Common Standard

All C2 systems could quickly migrate to the same standard and to put in place a Configuration Management (CM) and fielding process to keep fielded systems aligned.

5.1.2 Mitigation Server

A set of mitigation servers could be implemented that would convert between all of the existing and planned standards.

5.1.3 A Standard and Conversion Software

A standard for interoperability could be selected and then each system could implement conversion software. A common CM and fielding process would also have to be implemented.

5.1.4 A Standard and Mitigation Servers

A standard for interoperability could be selected. A set of mitigation servers could be implemented that would convert between all of the existing and planned standards and the standard. A common CM and fielding process would also have to be implemented.

5.1.5 A Standard with Mitigation Servers and Conversion Software

A combination of solutions 3 and 4 above could be implemented.

5.2 Programmatic Solutions

Programmatic improvements can help with the improvement of interoperability. However, they can be very difficult to implement.

5.2.1 Alignment of Programs

The C2 and M&S programs could be aligned to provide updates/changes to interoperability standards based interfaces at the same time.

5.2.2 Assigning Oversight

An organization (existing or newly formed) can be given the responsibility and authority to ensure interoperability across C2 and M&S systems. It would also have to be resourced.

6. Issues/Barriers

Programmatic solutions are very hard to implement. Current DoD acquisition processes are grounded in the management of systems. Implementing cross program/system processes would conflict with the responsibility and authority of the program/project

managers. In addition, resources would have to be extracted from the existing programs in order to effectively implement a cross system/program process. The Software Blocking program and the SIMCI program are examples of cross system/program efforts that have had some success. However, their authority is not strong enough to be fully effective.

Alignment of programs can only be partially implemented due to the variables impacting the program schedules (e.g. funding, program slips, technology failures). Interoperability alignment can be set up for timeframe fieldings. However resources and authority have to be included.

The largest issue with various technology alternatives is the impact on existing systems/programs. Currently there is no process controlling or aligning technology migration/transition activities. If this situation is not improved, then technology solutions will be implemented in an uncoordinated stovepipe manner which could result in a degradation of existing interoperability.

7. References

[1] Carr, F.H. and Hieb, M.R.: "Issues and Requirements for Future C4ISR and M&S Interoperability," 7th Conference on Computer Generated Forces and Behavioral Representation, Orlando, FL, 1998.

[2] SIMCI WWW Site, Army Overarching Integrated Product Team for Simulation to C4ISR Interoperability, https://simci.army.mil, 2002.

[3] Hieb, M.R., and Blalock, J., "Data Alignment Between Army C4I Databases and Army Simulations", Paper 99S-SIW-034, Spring Simulation Interoperability Workshop, Orlando, FL, 1999.

[4] Haugh, B.A., Wartik, S.P., Loaiza, F. and Hieb, M.R.: "A Comparison of the Land C2 Information Exchange Data Model and the WARSIM Object Model," Paper 02S-SIW-053, 2002 Spring Simulation Interoperability Workshop, Orlando, FL, March 2002.

[5] Future Combat System (FCS) Web Site, [http://www.army.mil/fcs], 2007.

[6] PEO STRI Web Site, Joint Land Component Constructive Training Capability (JLCCTC)), [http://www.peostri.army.mil/PRODUCTS/JLCCTC/], 2007.

[7] DISA Web Site, Net Enabled Command and Control (NECC), [http://www.disa.mil/necc/index.html], 2007.

[8] PEO STRI Web Site, Products for Live, Virtual, Constructive Integrating Architecture (LVC-IA), http://www.peostri.army.mil/PRODUCTS/LVCIA/, 2007.

Biographies:

Christopher Black is a Senior Systems Analyst with the Colsa Corporation. He currently supports the SIMCI and Intra Army Interoperability Certification process as the Program Executive Officer Simulation Training and Instrumentation (PEO STRI) Liaison working in the Central Technical Support Facility at Fort Hood, Texas. Mr. Black has over twelve years experience integrating and testing simulations with the Army Battle Command System (ABCS) development process, and has been a part of the Army C4I and Simulation Initialization System effort since its inception in FY02. He also serves as the lead architect for the SIMCI OIPT. Mr. Black's simulations experience is based on over 25 years in the United States Army where he used simulations for operational tests and unit training, and training simulation management at HQDA, G3. Mr. Black has a Bachelor of Arts degree from Clemson University.

Richard F (Dick) Brown is a consultant to the Battle Command Battle Laboratory working under contract for Billy Murphy and Associates. His current work focuses on simulations and C3 systems interoperability. Over the last 25 years he has worked on tactical fire control systems, integrated equipment and processes that form command posts and several communications systems. Mr. Brown is a 1967 graduate of the University of Massachusetts with a BS in Experimental Psychology. He retired from the US Army Reserve as a lieutenant colonel in 1997. He retired from the US Civil Service in 2006 after more than 39 years.

Stanley H. Levine is Research Professor at George Mason University. He also serves as a senior consultant to several Army and Department of Defense organizations in the areas of information system technologies, architectures, System of Systems acquisition, and interoperability. He has over 36 years experience in systems acquisition. He holds a Bachelor of Science degree in Electronic Engineering and a Master of Science degree in Physics from Monmouth University, and a PhD in Engineering Management

from Madison University. Dr. Levine served in many Army civilian positions (including the Senior Executive Service) for over 31 years. He concentrated on Command and Control systems research and development. Dr. Levine is a recipient of over 60 awards, commendations, and letters of appreciation including the Army's three highest Civilian Service Awards. He was selected to be a member of the Federal 100 top executives who had the greatest impact on the government information systems community. Dr. Levine has published 35 papers on a wide variety of technical and management subjects. He has also been a keynote or invited speaker at 33 major national or international symposiums and conferences.

William P. Sudnikovich is a Project Manager for Atlantic Consulting Services in Shrewsbury, NJ and a technical architect for the Army's SIMCI OIPT. Mr. Sudnikovich also supports the Army's CIO/G6 office through the Army Net-Centric Data Strategy Center of Excellence at Ft. Monmouth, NJ. Prior to joining ACS Mr. Sudnikovich held various technical and management positions with the US Army CECOM RDEC and was influential in establishing M&S activities there. He was an active contributor to the development of the IEEE 1278 DIS standard and is a former Chairperson of the C4I Forum of the Simulation Interoperability Standards Organization. Mr. Sudnikovich holds BS and MS degrees in Computer Science from Rutgers University and Fairleigh Dickinson University.

Interoperability Problems Caused by Transitioning to a Service Oriented Environment

Chris Black, Dick Brown, Stan Levine, Bill Sudnikovich
Simulation to C4I Interoperability (SIMCI)

Paper 24

AFCEA-George Mason University Symposium
"Critical Issues in C4I"

May 20-21, 2008

1

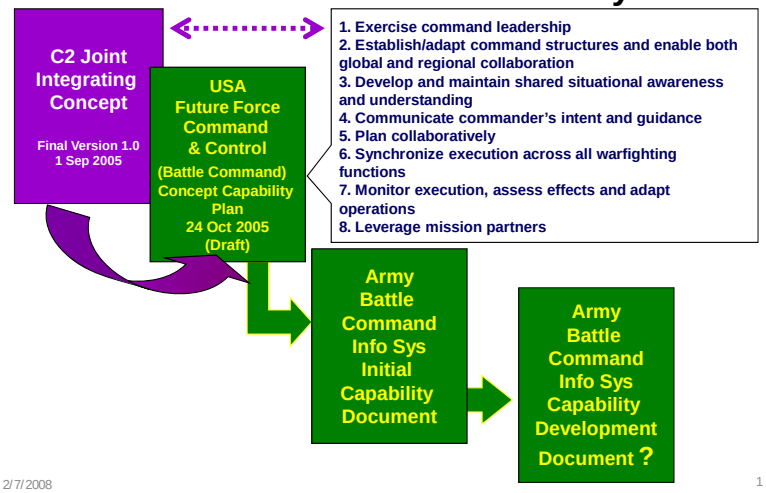
Outline

- Requirements
- Current programs
  - ABCS, FCS, LVC-IA
- SIMCI
- Technical Challenges
- Potential Solutions
  - Technical
  - Programmatic
- Issues/Barriers

2

Capability Documenting

Concept Capability Plan for the Battle Command System…



Capability Definition

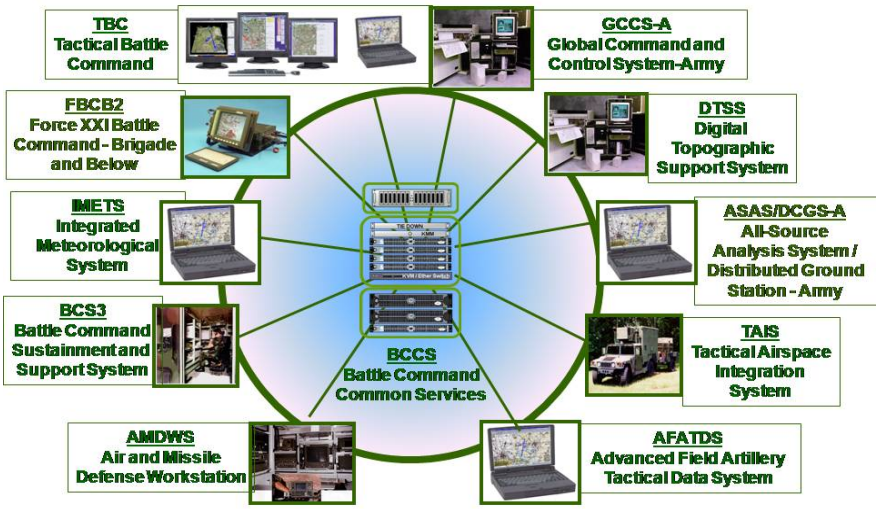
The ability to achieve a *desired effect*
- Under specified standards and conditions
- Through combinations of means and ways to perform a set of tasks

Defined by an operational user

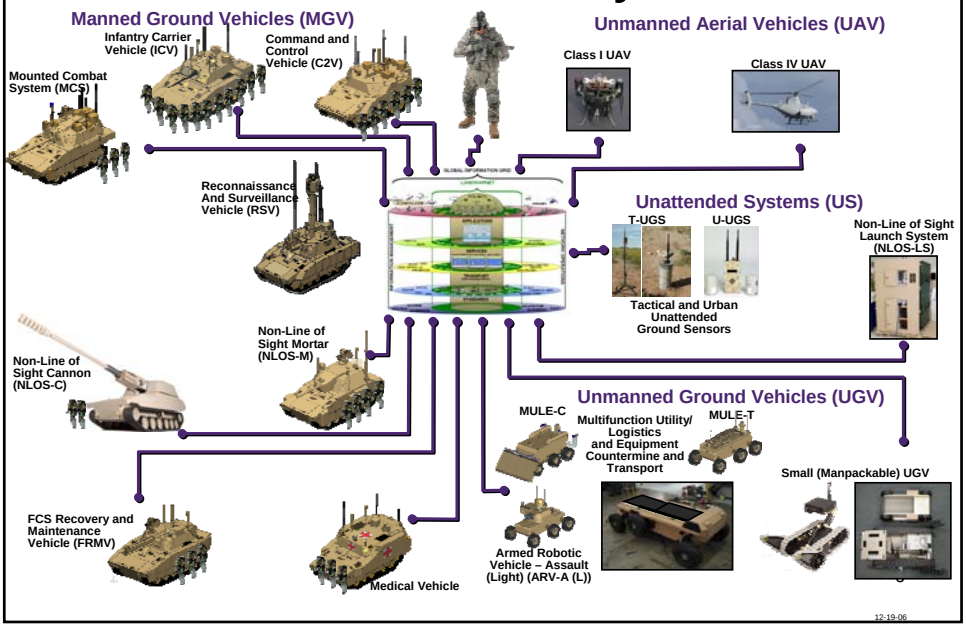
Expressed in broad operational terms in the format of a joint or initial capabilities document or a joint DOTMLPF change recommendation.

For materiel proposals, the definition will progressively evolve to DOTMLPF performance attributes identified in the capability development document and the capability production document.

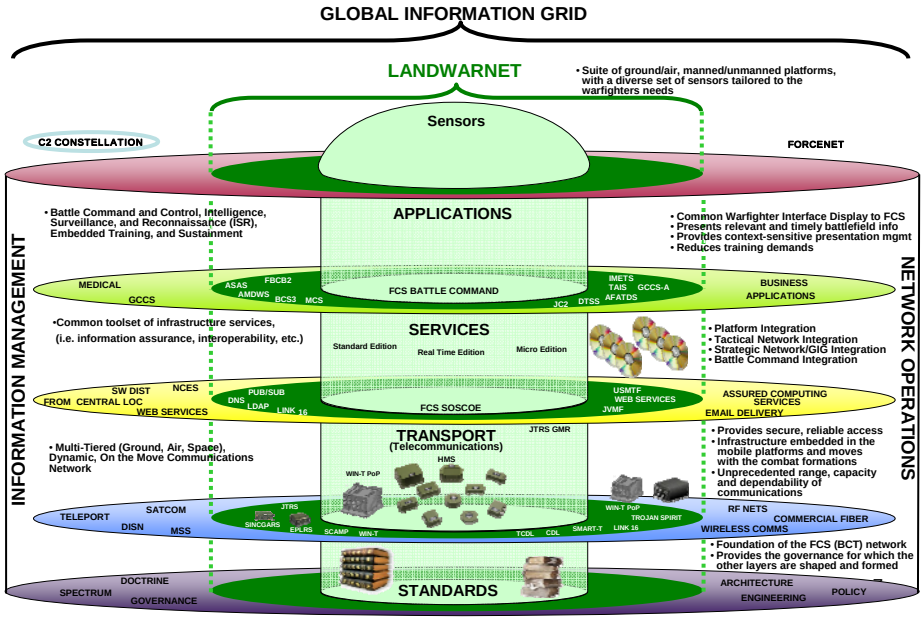
Army Battle Command System

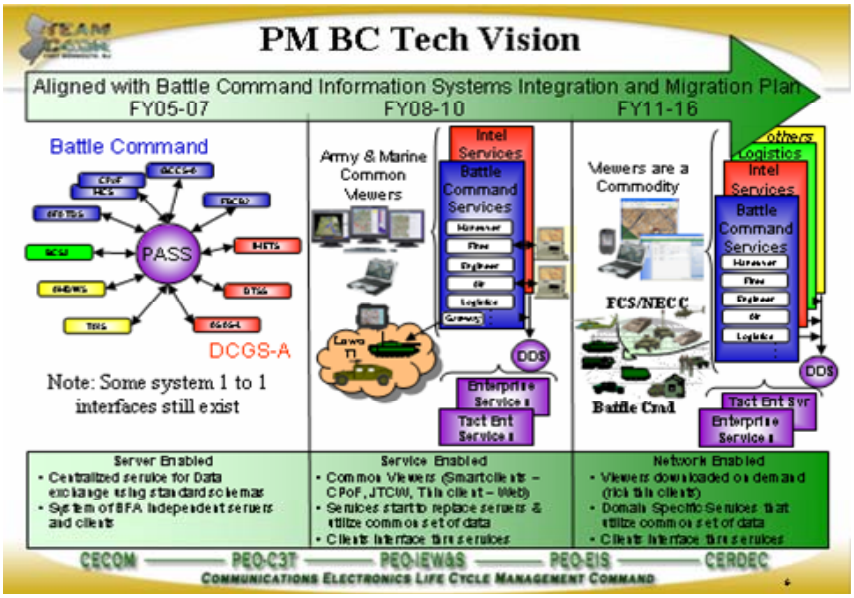


Future Combat Systems

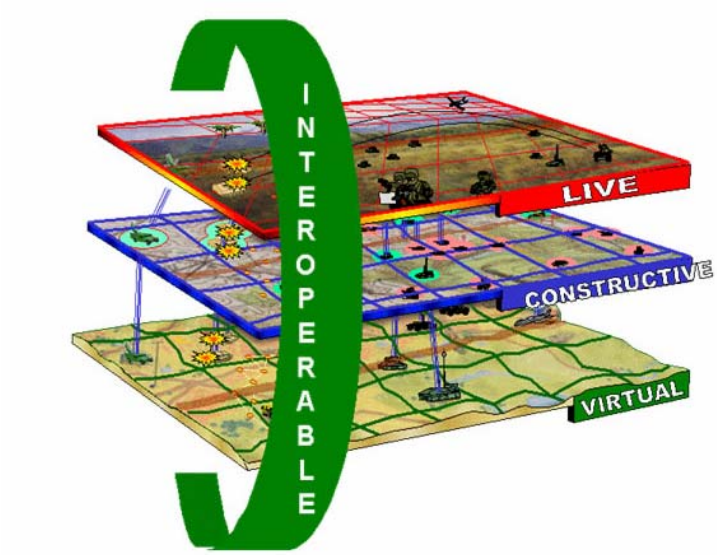


FCS(BCT) Network and the GIG



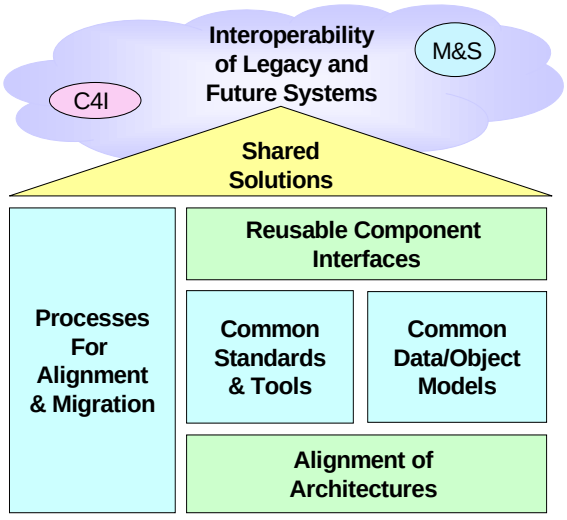


LVC-IA



9

SIMCI House Chart



10

Technical Challenges

- Ensuring cost effective, interoperability of ABCS, FCS, and M&S systems as they migrate will involve **many technical challenges**
- The key to identifying those challenges is use of a framework like that developed in the house chart coupled with an effective process that not only identifies the challenges but develops **coordinated and integrated solutions**.
  - Processes for Alignment & Migration
  - Alignment of Architectures
  - Common Data
  - Common Standards
  - Reusable Component Interfaces

11

Potential Solutions

- An organization's people and equipment must effectively interoperate.
  - focused on location and date
- Each specific Unit is not standard and can change over time.
- Any enterprise wide solution must take into consideration the interoperability requirements caused by the deployment of system versions.

- Technical Solutions
- Programmatic Solutions

12

Technical Solutions

- Common Standard
  - All C2 systems could quickly migrate to the same standard and to put in place a Configuration Management (CM) and fielding process to keep fielded systems aligned.
- Mitigation Server
  - A set of mitigation servers could be implemented that would convert between all of the existing and planned standards.
- A Standard and Conversion Software
  - A standard for interoperability could be selected and then each system could implement conversion software. A common CM and fielding process would also have to be implemented.
- A Standard and Mitigation Servers
  - A standard for interoperability could be selected. A set of mitigation servers could be implemented that would convert between all of the existing and planned standards and the standard. A common CM and fielding process would also have to be implemented.

13

Programmatic Solutions

- Alignment of Programs
  - The C2 and M&S programs could be aligned to provide updates/changes to interoperability standards based interfaces at the same time.
- Assigning Oversight
  - An organization (existing or newly formed) can be given the responsibility and authority to ensure interoperability across C2 and M&S systems. It would also have to be resourced.

14

Issues/Barriers

- Programmatic solutions are very hard to implement
  - Current DoD acquisition processes are grounded in the management of single systems
  - Implementing cross program/system processes would conflict with the responsibility and authority of the existing program/project managers
  - Resources would have to be extracted from the existing programs in order to effectively implement a cross system/program process.
- Alignment of programs can only be partially implemented due to the variables impacting the program schedules (e.g. funding, program slips, technology failures).
  - Interoperability alignment can be set up for timeframe fieldings. However resources and authority have to be included.
- The largest issue with various technology alternatives is the impact on existing systems/programs.
  - Currently there is no process controlling or aligning technology migration/transition activities.

15